MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

EME1046 – PRINCIPLES OF THERMODYNAMICS

(ME)

4 MARCH 2019
2.30 p.m – 4.30 p.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 4 printed pages (including cover page and appendix) with four questions.
2. Attempt **ALL FOUR** questions. Each question carries 25 marks.
3. Please write all your answers in the Answer Booklet provided.
4. All necessary workings must be shown.
5. A property tables booklet is provided.

Question 1

(a) Air is contained in a vertical, frictionless piston cylinder. The pressure of air is at 180 kPa gage pressure. The piston has a diameter of 5.0 cm. If the atmospheric pressure is 95 kPa, determine the mass of the piston. Use $g = 9.81$ m/s^2.

[5 marks]

(b) A piston cylinder initially contains 5.5 m^3 of water as saturated vapor at 90 °C. Water is then being compressed until its temperature and pressure are 250 °C and 300 kPa, respectively. During the compression process, 200 kJ of heat is transferred to the water.

(i) Determine the mass of water in the piston cylinder. [3 marks]

(ii) Determine the initial pressure of water vapor. [1 mark]

(iii) Determine the work done on the system in kJ and the final volume. [7 marks]

(iv) Determine the volume change in this process. [2 marks]

(c) A 10 m^3 tank initially contains argon at 30 °C and 450 kPa. Some argon is then added to the tank until the pressure in the tank increases to 800 kPa. If the temperature at this point is 35 °C, determine the amount of argon added.

[7 marks]

Question 2

(a) Air is compressed steadily in a well-insulated compressor from 200 kPa and 280 K to 500 kPa and 500 K. The mass flow rate of the air is 0.05 kg/s. Assuming the changes in kinetic and potential energies are negligible, determine the power input to the compressor.

[7 marks]

(b) Steam at 5 MPa and 500 °C is expanded in an adiabatic turbine steadily to 1 MPa and 300 °C. Steam enters the turbine through a 0.01 m^2 opening with an average velocity of 50 m/s. Steam leaves the turbine through a 0.02 m^2 opening.

(i) Determine the mass flow rate of steam through the turbine. [5½ marks]

(ii) Determine the velocity of steam at the exit of the turbine. [3½ marks]

(iii) Determine the power produced by the turbine. [9 marks]

Continued ...

Question 3

(a) 5 kg of air is contained in a piston-cylinder device. Air is now heated at constant pressure from 50 °C to 100 °C. Determine the amount of heat transferred, by assuming:

(i) constant specific heats for air.
Use $c_p = 1.005$ kJ/kg·K and $c_v = 0.718$ kJ/kg·K. [6½ marks]

(ii) variable specific heats for air. [3½ marks]

(b) A refrigeration cycle removes heat (Q_L) from a low-temperature reservoir at $T_L = 303$ K and rejects heat (Q_H) to a high-temperature reservoir at $T_H = 423$ K. Determine whether the following refrigeration cycles are reversible, irreversible or impossible.

(i) $Q_H = 850$ kJ, $Q_L = 650$ kJ. [6 marks]

(ii) $Q_H = 850$ kJ, $W_{net,in} = 350$ kJ. [3 marks]

(c) A refrigerator is used to maintain a house at 293 K by rejecting heat from the house to the surrounding at 308 K. The entire mass within the house is estimated to generate heat at a rate of 100000 kJ/h. The refrigerator consumes 3 kW of power when running. Is this refrigerator powerful enough to do the job?

[6 marks]

Question 4

(a) Refrigerant-134a enters an isentropic compressor at 100 kPa and 40 °C and leaves at 600 kPa. The mass flow rate of refrigerant-134a is 5 kg/s. Assuming the changes in kinetic and potential energies are negligible, determine the exit temperature of refrigerant-134a and the power input to the compressor.

[9 marks]

(b) Air is expanded in a turbine in a reversible and adiabatic manner. The temperature of air at the turbine exit is 497 °C. If the pressure ratio P_1/P_2 of this turbine is 8, determine the temperature of air at the turbine inlet and the work output of the turbine. [Hint: P_1 is the inlet pressure and P_2 is the exit pressure.]

(i) Assume variable specific heats for air. [11 marks]

(ii) Assume constant specific heats for air.
Use $c_p = 1.005$ kJ/kg·K, $c_v = 0.718$ kJ/kg·K and $k = 1.4$. [5 marks]

Continued ...

APPENDIX

Uniform State Uniform Flow (Unsteady Flow)

Continuity:

$$(m_2 - m_1) = \sum_i m_i - \sum_e m_e$$

First Law:

$$Q_i + W_i + \sum_i m_i\left(h_i + \frac{V_i^2}{2} + gZ_i\right) - Q_e - W_e - \sum_e m_e\left(h_e + \frac{V_e^2}{2} + gZ_e\right)$$
$$= m_2\left(u_2 + \frac{V_2^2}{2} + gZ_2\right) - m_1\left(u_1 + \frac{V_1^2}{2} + gZ_1\right)$$

Second Law:

$$m_2 s_2 - m_1 s_1 = \sum_i m_i s_i - \sum_e m_e s_e + \int_0^t \frac{\dot{Q}_{cv}}{T} dt + {}_1S_{2\,gen}$$

Ideal Gas

Ideal Gas Equations of State

$$Pv = RT$$
$$dh = C_p dT$$
$$du = C_v dT$$

Specific Heats and Ideal Gas Constants

$$C_p - C_v = R$$
$$\frac{C_p}{C_v} = k$$

Entropy Relationships

$$s_2 - s_1 = C_v \ln\frac{T_2}{T_1} + R\ln\frac{v_2}{v_1} \quad \text{if constant } C_v$$
$$= C_p \ln\frac{T_2}{T_1} - R\ln\frac{P_2}{P_1} \quad \text{if constant } C_p$$
$$= s^0_{T_2} - s^0_{T_1} - R\ln\frac{P_2}{P_1} \quad \text{otherwise}$$

For polytropic process

$$PV^n = c$$
$${}_1W_2 = \frac{P_2V_2 - P_1V_1}{1-n} \quad n \neq 1$$
$$= P_1V_1 \ln\frac{V_2}{V_1} \quad n = 1$$

End of Paper.